

Integration of information technology into the enterprise's energy management system in accordance with the ISO 50001:2018 standard

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Abstract. This article analyzes the formation of a modern product quality management system based on detailed research and prioritization of the enterprise's business processes, documenting reorganized processes in the form of model representations, and organizing information support. Key principles and tactics for applying information technology in quality management using CALS technologies are also considered. The design and management of a quality system based on CALS approaches are substantiated. In addition, the article is devoted to the study of the implementation of information technologies in the energy management system in accordance with the ISO 50001:2018 standard, including monitoring energy consumption, developing energy policy, determining energy efficiency indicators (EnPI), and forming an energy consumption database (EnB).

INTRODUCTION

The modern approach to quality management involves a fundamental restructuring of the enterprise's activities, encompassing practically all tasks facing it in areas such as strategy, organizational structure, business processes, personnel management, and automation [1-2].

In today's realities, it is difficult to imagine a sphere of human activity where information technologies are not applied. The automation of various procedures, the equipping of workplaces with computer equipment, and the introduction of advanced methods for processing, using, and exchanging information represent powerful tools for increasing work efficiency and improving people's interaction within society [3-4].

The introduction of modern information technologies into the production sector has made it possible to optimize the solution of complex engineering problems and develop innovative methods and technical means for their implementation. These changes stimulated the development of advanced technological processes designed to produce more complex and science-intensive products [5-6].

In today's environment, improving energy efficiency is becoming an important area of enterprise development. The international standard ISO 50001:2018 establishes requirements for the creation of an energy management system (EMS) aimed at the rational use of energy resources, reducing energy costs, and enhancing the environmental sustainability of the enterprise. Integrating information technology into energy monitoring and analysis processes can significantly improve the efficiency of energy management [7-8].

Today, companies implement international quality standards ISO 9001:2015 to ensure the efficient operation of their departments. Based on practical experience and statistical research, the most popular quality management system models of all existing options are ISO 9001:2008, TickIT, and SEI SWCMM [9-10].

In addition to the quality management system, the ISO 50001:2018 energy management system, which offers an ordered method for improving the energy efficiency of enterprises, is gaining increasing importance. Unlike ISO 9001, which focuses on product quality, ISO 50001 focuses on energy resource management, identifying key

aspects of energy consumption, defining energy goals and indicators, and continuously improving energy efficiency [11-12].

Modern quality management represents a comprehensive tool aimed at improving and controlling all operations within the organization, including management operations. The presence of an international certificate confirming the compliance of the quality management system is a universally recognized confirmation of the company's high level of technological development and its compliance with current scientific and technical standards. This certificate, valued worldwide, demonstrates the organization's commitment to best practices and innovation [13-14].

Today, the implementation of a quality management system is voluntary, but at the same time, no reputable company in Europe will contract with a company that has not achieved ISO 9001:2015 certification. To create an effective quality system based on the ISO 9001:2015 series, companies typically also utilize additional industry standards and their own regulatory documents and developments [15-16].

The effectiveness of the application of modern information technologies is determined by the correspondence between the levels of quality management and the areas of application of computer technologies [17-18].

The most important areas of using computer technologies at various levels of quality systems include [19-25]:

- control place at the control point, computer technologies are used to control and determine measured values when working with control machines and measuring machines. They are also used to operate simple measuring instruments to receive measured values, eliminating transmission errors caused by human error. Increasing automation leads to the wider use of computer technologies. At the same time, the boundary between humans and the processing computer system for determining the values of the characteristics being tested is becoming increasingly clear.

- quality control management. The quality control management layer ensures the transfer of necessary information and serves to consolidate the data obtained at a single control point. This consolidation can be accomplished in three ways:

- a) by determining the values of the characteristics being tested from the measured values by calculation or comparison with the specified values;

- b) processing of the verified characteristics using statistical methods;

- c) the derivation of correction parameters for process regulation. Control-level tasks can be expressed by algorithms and, therefore, are easily accomplished using computers.

- organization management. At this level, which includes storing data obtained during control, determining control costs, and analyzing products, information technology is used to transmit information. At the same time, it is necessary to conduct market research, understand changing needs, and determine necessary product requirements.

- quality management. The primary task at the quality management level is the evaluation of inspection data. This is typically performed by organizational personnel who utilize computer data in their work. Within factory networks, it is necessary to integrate a quality data transmission system and emphasize multimedia computer technologies.

Work on the development and implementation of CALS technologies has been underway abroad for over 25 years. Significant results have been achieved in this area. CALS technologies are currently considered a beneficial global economic strategy across all industries [26-27].

The term CALS (Continuous acquisition and lifecycle support) means a set of principles and technologies for information support of the product life cycle at all its stages [1-2, 28-29].

EXPERIMENTAL RESEARCH

The goal of implementing CALS is to minimize costs during the product life cycle, improve its quality and competitiveness [30-31]. In today's landscape of resource stewardship, enhancing energy efficiency is emerging as a key strategic goal for businesses. Adopting an energy management framework aligned with ISO 50001 offers a pathway to reduce energy expenditures throughout a product's entire journey. This standard mandates a thorough examination of energy usage, pinpointing major consumption points, formulating a clear energy strategy, building a comprehensive energy data repository, and defining metrics for tracking energy performance (EnPIs). To ensure information integration, CALS uses IGES and STEP standards as data formats. CALS also includes standards for electronic data exchange, electronic technical documentation, and process improvement guidelines [32-33].

In developed countries, CALS is considered as a comprehensive systemic strategy for improving the efficiency of processes associated with knowledge-intensive industrial products, which directly affects their quality and competitiveness [34-35].

CALS Strategy The CALS method involves the creation of an enterprise information space that enables the storage of information electronically and serves as a single data source for all participants in the product lifecycle. The CALS method defines the enterprise information space (IS) as a repository of all product information, the sole source of product data (direct data exchange between lifecycle participants is excluded), and is based on international, national, and industry standards [36-37].

Likewise, ISO 50001 mandates a centralized information hub for energy consumption data storage and analysis. IT solutions empower automated data acquisition from devices, live monitoring of energy use, statistical insights into energy patterns, and the creation of improvement strategies for greater efficiency. The CALS strategy involves two stages of creating a unified information space [38-40]:

- automation of individual processes of the product life cycle and presentation of data on them in electronic form in accordance with international standards;
- integration of automated processes and related data within a single information space.

The following methods are used to implement the CALS strategy [41-45].

1. Business process analysis and reengineering technologies are methods for restructuring enterprise operations. These technologies enable a smooth transition from paper-based to electronic document management and the implementation of new product development methods (parallel engineering, interdisciplinary working groups, etc.) within the automation process.

2. Technologies for presenting product data - methods for standardized electronic presentation of data related to individual processes of the product life cycle.

3. Product data integration technologies - methods for integrating automated life cycle processes and related data.

Product data management systems are used to integrate all data within an IP. Their purpose is to accumulate all information generated by application systems into a single model. The interaction between these systems and application systems is based on standard interfaces, which can be roughly divided into four groups [46-49].

1. Functional standards - track the organizational procedure for interaction between computer systems. For example, in the IDEF (Integrate Computer Automated Manufacturing Definition) standard (IDEF0 - a family of methods and technologies for creating complex systems and designing computer systems), IDEF0 is a functional modeling standard.

2. Information standards – provide a data model used by all lifecycle participants. For example, ISO 10303 STEP.

3. Software architecture standards – define the architecture of software systems necessary for interaction without human intervention. For example, COBRA.

4. Communication standards – specify the method for physically transmitting data over local and global networks. For example, internet standards.

CALS methodology It is independent of the subject area and is actively used in the development of complex, science-intensive products for both military and civilian applications, whose lifespan, including various upgrades, spans decades. Typically, it is developed with the involvement of numerous subcontractors, and the CALS philosophy emphasizes transparent and easy communication between contractors and customers [50-51].

An enterprise's quality system (QS) is an element of its management activities. From this perspective, the QS is viewed as a subsystem of the enterprise, tightly integrated with the information environment. Therefore, CALS technologies can be applied to its design, creation, operation, analysis, and reengineering (reorganization). Similarly, an energy management system (EMS) is part of the overall enterprise management system. It integrates with existing information systems and enables automation of processes for monitoring, analyzing, and optimizing energy consumption [52-53].

To implement organizational and regulatory-methodological support for SC CALS technologies, it is necessary to use functional models of enterprise processes from the point of view of quality assurance [54].

Clearly, the QS must be based on an information system that supports automated documentation of quality assurance processes at all stages of the product lifecycle and automated management of these processes. This means that all data circulating in the QS must be presented in formats regulated by CALS standards and comprise a set of information models that are part of the enterprise's integrated information system [55-56].

The use of CALS technologies in the field of creating quality control systems at all stages of the product life cycle facilitates continuous quality improvement and allows enterprise management to ensure that all technical, administrative, and human factors affecting the quality of manufactured products are under control, and that quality control management takes into account consumer needs and expectations and ensures the enterprise's competitiveness [57-58].

RESEARCH RESULTS

Development and management of a quality system based on the principles of CALS technologies. Management of organizational and technical systems based on CALS technologies refers to the field of science and technology, which includes a set of methods and means of human activity aimed at the analysis, design and management of complex organizational and technical systems and the processes of their functioning based on modern computer systems and technologies [59-60].

The objects of development and management of organizational and technical systems are the modeling of organizational and technical systems, namely: organizational, technological and production processes; after-sales service processes; their functioning on the basis of automated control and monitoring systems, mathematical, information, technical and software support, i.e. those production objects that should be covered by a quality system created on the basis of modern computer technologies [61-62].

Therefore, to develop a quality system based on CALS technologies, covering the above-mentioned production facilities, it is necessary to complete [63-65]:

- construction of mathematical models of technical systems, technological processes and production as objects of automation and control, including the use of numerical methods for studying systems and operations and combinatorial analysis;
- development of models and methods for solving problems of analysis and synthesis of organizational and technical systems and their operational operations, as well as the refinement of algorithmic and software support for automation and control systems for objects of various physical natures under the conditions of a specific enterprise;
- implementation and refinement of modern hardware and software for research, design, technical diagnostics and industrial testing of automation and control systems and equipment;
- analysis of information, methods of its storage, processing and transmission using methods of combinatorial analysis;
- analysis of the features of mathematical calculations implemented in automated design and project management systems, as well as in logistics support systems using methods of mathematical analysis, operational calculus, probability theory and mathematical statistics;
- to provide directions for improving the technology of system modeling using the fundamentals of mathematical logic and the theory of logical inference;
- take into account the problematic issues of establishing the uncertainty of the states of organizational and technical systems and the operations of their functioning.

Conducting an energy analysis in accordance with ISO 50001 and identifying significant areas of energy consumption [40-49]:

- development of energy policy and energy goals of the enterprise;
- determination of energy indicators (EnPI) and formation of an energy database (EnB);
- implementation of energy consumption monitoring and measurement systems using digital technologies;
- analysis of risks and opportunities associated with energy consumption.

For the effective operation of quality management systems created on the basis of CALS technologies, it is also necessary to implement a number of organizational measures, such as [51-59]:

- development of conceptual and formal models of organizational and technical systems and processes of their functioning, using probability-theoretical methods of calculation and study of the characteristics of organizational and technical systems;
- organization of the development process and solution of problems of management of organizational and technical systems based on the principles and methods of object-oriented modeling technology through automation systems and management of a given quality;
- organizing the work of a team of developers of a quality management system in a unified information space,
- making management decisions based on current and reliable data provided by the product lifecycle support system (PLM system), as a component of the CALS technology software;
- planning the phased development and implementation of automation and control systems and tools based on a PLM system;
- selection of technology, tools and computing equipment in organizing the processes of research, design, technical diagnostics and industrial testing of automatic and automated control and management systems.

Ensuring the operability of the PLM system in a single information space, organizing the object management system in the PLM system based on solving the problems of studying the efficiency of the functioning of organizational and technical systems [60-70]:

- training of personnel within the framework of the adopted organization process of development and implementation of automation and control systems and tools.
- organization of monitoring and measurements of energy consumption in accordance with the requirements of ISO 50001;
- conducting internal audits of the energy management system;
- ensuring continuous improvement of the energy performance of the enterprise based on data analysis.

CONCLUSIONS

The above approaches to developing a quality system based on CALS technologies will allow us to obtain real data on the progress of production processes, based on which we can make timely, informed decisions to improve their quality, and, consequently, the quality of manufactured products.

Therefore, building a modern product quality management system should be based on a thorough analysis and reengineering of enterprise processes, documenting the restructured processes in the form of models, and creating information support for the quality management system. Its use will enable every enterprise to obtain an effective tool for improving the quality of its products.

Integrating ISO 50001 standards into an enterprise's information system enables systematic energy management, increases production energy efficiency, and reduces costs. The use of digital technologies makes energy monitoring processes more transparent, and energy resource management more efficient and cost-effective.

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